Volume 32
Number 368 *Stabilizing corn supplies by storage*

Article 1

August 2017

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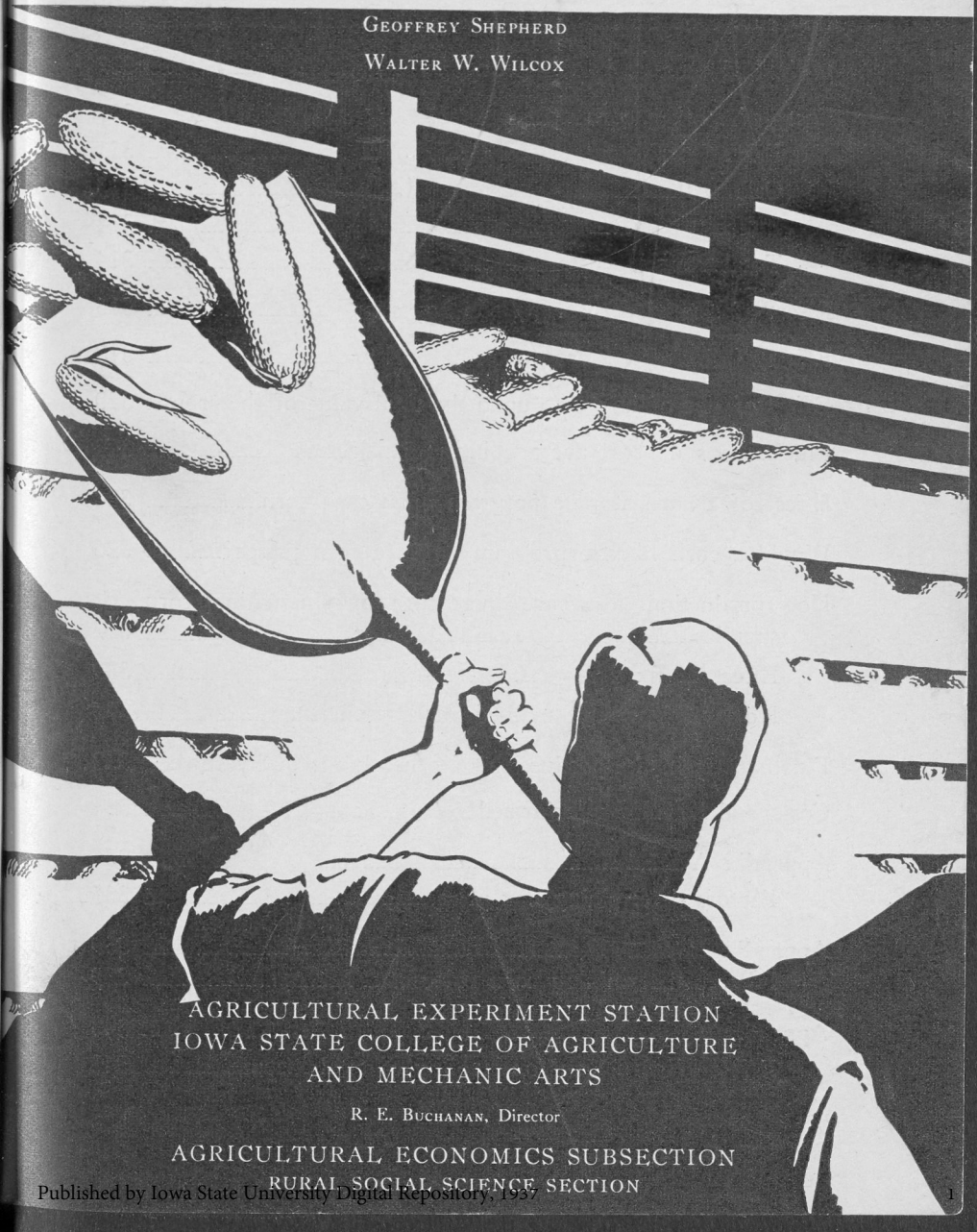

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

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AGRICULTURAL ECONOMICS SUBSECTION
RURAL SOCIAL SCIENCE SECTION

CONTENTS

SUMMARY

Farmers, acting as individuals, ordinarily carry over some of their surplus corn from big crop years to small crop years. This storage has had the effect of reducing fluctuations in corn supplies, on the average, by one-fifth.

The best place to store the surplus corn from big crops is right on the farm where it was grown. The costs of this storage average about 3 cents per bushel per year.

EFFECT OF FLUCTUATIONS IN THE SIZE OF THE CORN CROP

Fluctuations in corn production directly cause corresponding fluctuations in hog production between 1 and 2 years later. A large corn crop soon shows up as a large hog crop, and a small corn crop soon shows up as a small hog crop. The change in the hog crop is about the same size as the change in the corn crop that caused it. A 10 percent change in the corn crop, for example, causes about a 10 percent change in the hog crop.

A change in corn supplies causes a greater change in the opposite direction in corn prices. The same thing is true of hogs. A large crop of corn is therefore worth less than a small crop; so is a large crop of hogs. The sequence of causation, then, is (1) a large corn crop causes (2) a large hog crop which (3) sells for less money than a small crop. A large corn crop, however bountiful and beneficial it appears at the time, soon shows up in reduced total income from hogs.

This means that when the corn crop is large, and corn prices and total incomes from corn are low, farmers as a group do not escape the effect of these low corn prices and incomes by feeding the corn to livestock more heavily; they merely translate it into lower hog prices and incomes a year or two later. The decrease in hog prices and total incomes is approximately equal to the decrease in corn prices and incomes.

BENEFITS FROM STABILIZATION

Stabilizing corn supplies, therefore, would stabilize hog (and other livestock) supplies, prices and total incomes and would slightly raise total incomes as well. Smoothing out livestock pro-

duction would also reduce livestock production, marketing and processing costs.

It is difficult to measure these two benefits accurately (the slight increase in total income and the decrease in costs) but preliminary calculations indicate that the benefits would be several times greater than the storage costs.

Stabilizing Corn Supplies by Storage[1]

By Geoffrey Shepherd and Walter W. Wilcox

Farmers have always been troubled by instability. Crops, prices, incomes—all of them are uncertain, fluctuating, unpredictable. "Farming's a gamble." The farmer who plants 80 acres of corn in the spring may harvest 6,000 bushels, 3,000 bushels or perhaps no bushels at all in the fall. The hog producer who breeds his sows in December when hogs are selling at $8.00 per 100 pounds may sell the crop a year later at $6.00 or at $10.00. The cattle feeder who fills his pens when prospects are bright, may sell his cattle after they are finished for less per 100 pounds than he paid for them, or he may unexpectedly cash in large profits.

This instability results from fluctuations in two different things—in the supply of farm products and in the demand for them. Changes in demand have been all too evident during the past few years; they constitute one of the most important and difficult economic problems of our times. Changes in supply constitute a more definitely limited agricultural problem. This bulletin deals only with changes in supply and is furthermore restricted to the one supply area, the Corn Belt.

Changes in the supply of corn from one year to another are primarily the result of changes in the weather. Corn acreage remains relatively constant, close around 100 million acres. It was changes in the weather, not in acreage, that gave us the extremely short crops of 1934 and 1936 and the relatively large crop of 1937. These fluctuations in the corn crop concern Corn Belt farmers in their capacity of livestock producers as well as in their role of corn growers, for fluctuations in corn production and prices set up repercussions in the livestock industry that reverberate back upon corn production and prices later on, just as ocean waves breaking against a rocky shore are reflected back upon fresh incoming waves to cause double confusion.

If the primary cause of instability in Corn Belt agriculture is the weather, can anything be done about it? Nothing much

[1]Projects 462 and 520, Iowa Agricultural Experiment Station.

can be done about the weather. But corn is a relatively durable crop, and something can be done about the effects of the weather. The surplus resulting from good crop years can be stored over to short crop years and the effective market supplies leveled out, even though production continues to fluctuate.

This is such an obvious answer that the question arises at once—if it is advantageous to stabilize the market supplies of corn in some such manner as this, why has it not been done before? If the benefits from carrying over surplus corn from big crops and selling it in short crop years are greater than the costs, why has it not been done by independent, individual farmer action in the past?

There are two possible answers to this question. Either (1) farmers have been carrying surplus corn over after big crop years to such an extent that price fluctuations have been reduced to the point where they are only just sufficient to cover storage costs (in this case increasing storage operations further would reduce price fluctuations to the point where they would not cover costs, and this would result in a net loss); or (2) farmers do too little storing, because of lack of forecasting ability, insufficient equipment and financial power to carry grain long enough or insecurity of tenure which might result in their having to move before their storage operations were complete or some combination of these.

The answer to this question requires that a full examination be made of the nature of fluctuations in corn production in the past, their effect upon the livestock enterprise, the amount of storage done by individual farmers, the benefits that could be expected to follow upon concerted storage action and the costs involved. The whole field of investigation covers much more territory than corn supplies and prices; indeed, since more than 85 percent of the corn produced is fed to livestock, the direct effects of storage upon cash corn are comparatively unimportant. By all odds, the most important effects of stabilizing corn supplies are those which show up in livestock production, prices and total income. Major attention, therefore, will be given to livestock.

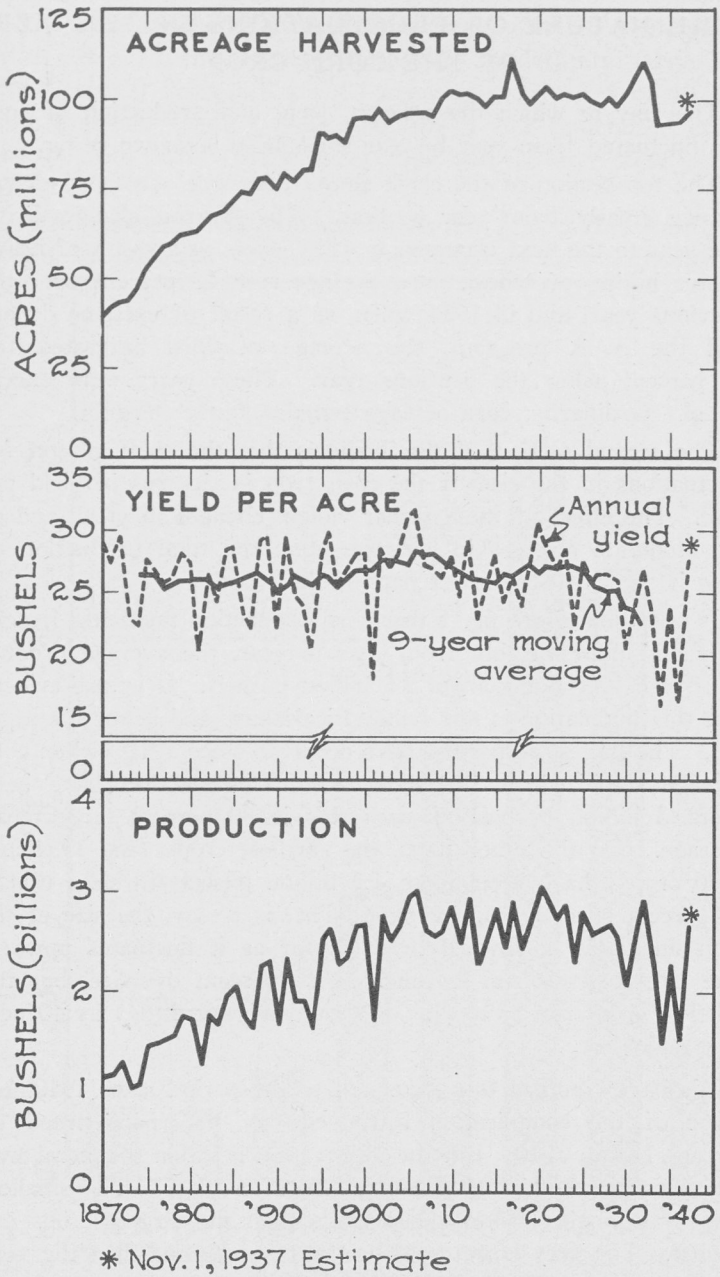

Fig. 1. Corn; acreage, yield per acre and production, United States, 1870 to 1937.

THE NATURE OF FLUCTUATIONS IN THE SIZE OF THE CORN CROP

The way in which the acreage, yield and production of corn has fluctuated from year to year since 1870 is shown in fig. 1.

The top section of the chart shows that corn acreage does not change greatly from year to year. The greatest changes from one year to the next occurred in 1917 when, as a result of heavy winter killing of wheat, corn acreage rose 10 percent over the previous year, and in 1934 when, as a result of extreme drouth and the AAA program, the acreage of corn harvested fell 13 percent below the previous year. These years were exceptional. Ordinarily, corn acreage remains fairly constant.

The second section of fig. 1 shows that the chief reason for fluctuations in the size of the corn crop is changes in yield per acre. The effect of these rather violent changes in yield, and of the moderate changes in acreage, upon the total production of corn is shown in the lower part of the chart.

It is evident from fig. 1 that corn production fluctuates irregularly and unpredictably from year to year, the average production since 1900 being about 2.5 billion bushels. It is also evident that this fluctuation is not symmetrical above and below the average. The largest crops that have occurred since 1910 (when corn acreage stabilized out at about 100 million acres) have been about 3 billion bushels in size; this is 20 percent larger than average. On the other hand, the smallest crops (the 1934 and 1936 crops) have been about 1.5 billion bushels in size; this is 40 percent smaller than average. That is to say, the size of the crop fluctuates downward twice as far as it fluctuates upward. The largest crops run as much as 20 percent oversize, but the smallest crops run as much (or should we say, little) as 40 percent undersize.

We have confined this statement to the period since 1910, because of the complication introduced by the rising trend of acreage before 1910. But the observation holds in a general way for the years before 1910 as well as after 1910. The smallest crops fall farther below the average than the largest crops exceed it. The very large crops are more numerous than the very small crops.

The same general observation holds true, over the whole period from 1870 to the present time, for **moderately** large and small crops. There are a good many crops about 5 or 10 percent oversize, whereas there are only a few undersized crops, and they run farther below the average than the large crops exceed it.

This is shown diagrammatically in fig. 2. In this chart, the height of each bar represents the frequency of occurrence of

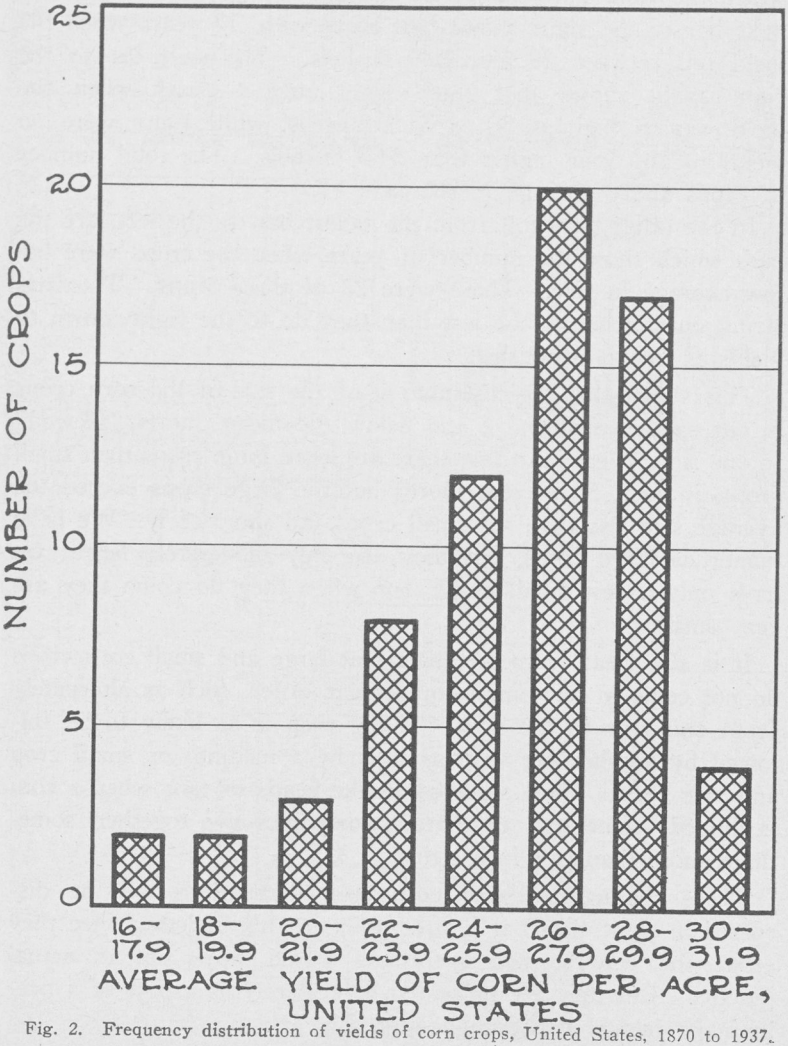

Fig. 2. Frequency distribution of yields of corn crops, United States, 1870 to 1937.

different sized corn crops. The size of the corn crop is represented by the yield, since using yields frees the presentation from the complication resulting from the rising trend in acreage before 1910.

The average yield for the periods from 1870 to 1937 as a whole was 26 bushels per acre. The tallest bar in the chart shows that during this 68 year period there were 20 years in which the yield fell between 26 and 27.9 bushels per acre. The next bar to the right shows that there were 17 years when the yield fell between 28 and 29.9 bushels. The next bar to the right again shows that there were only 4 years when the yield was as high as 30 to 31.9 bushels, while there were no yields in any year higher than 31.9 bushels. The total number of crops above average in size was 41.

In the other direction from the tallest bar, to the left, are the bars which show the number of years when the crops were below average in size. There were 27 of these crops. The bars string out farther to the left than they do to the right, down to yields as low as 16 bushels.

This shows that the distribution of the size of the corn crops is not symmetrical above and below the mean but is "skewed" to one side. That is to say, there are more large crops than small crops, in fact, 50 percent more; but the large crops exceed the average size less than the small crops fall short of it. We have numerous large crops, but they are only moderately large; we have only a few small crops, but when they do come they are very small.

It is also clear from the chart that large and small corn crops do not come in any simple or regular order, such as alternately from one year to the next. A big crop is as likely to be followed by another big crop as it is by a medium or small crop and vice versa. Corn crops come like heads or tails when a coin is flipped—sometimes alternately, sometimes two together, sometimes more than two in a string.

These characteristics of corn crop fluctuations will be discussed in some detail at a later point in this bulletin, since they affect the way storage operations would work out in actual practice. But they are presented here merely as a part of a preliminary factual background approach.

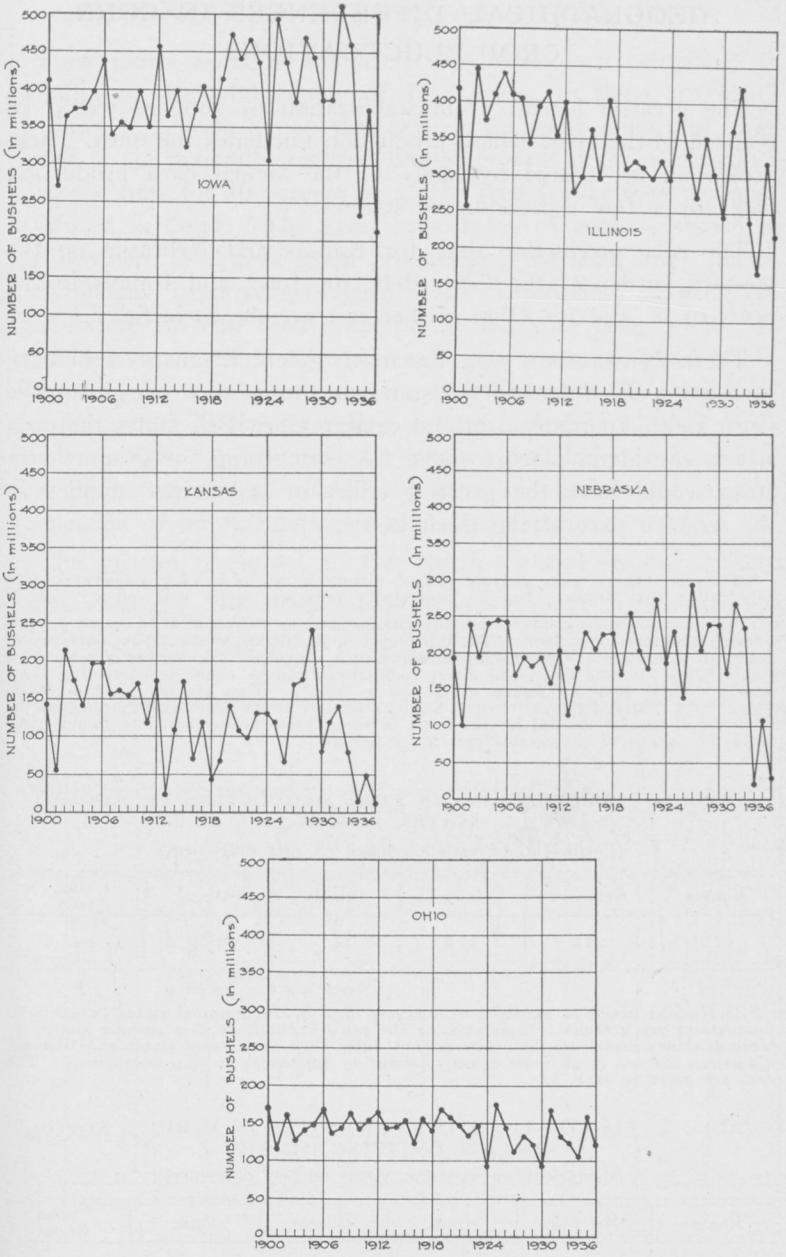

Fig. 3. Production of corn by representative states, 1900 to 1936.

GEOGRAPHICAL DIFFERENCES IN CORN CROP FLUCTUATIONS

The greatest benefit from stabilization of supplies would be realized in the areas where production fluctuates the most. These areas can be located by study of the annual corn production data for a few representative states.[2]

The corn production data for Kansas and Nebraska on the western border of the Corn Belt, for Iowa and Illinois in the heart of it and for Ohio farther east are shown in fig. 3.[3]

These figures show that the most violent fluctuations in corn production are found in the states on the western margin of the Corn Belt. In the central and eastern Corn Belt states the crop size is considerably more stable. A corn storage program, therefore, would have the greatest effect in stabilizing supplies in the western part of the Corn Belt.[4]

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[2]It would make a more sharply defined picture if type-of-farming areas were used here rather than states. But for preliminary purposes, states will suffice.

[3]Fig. 3 shows the extent of the fluctuations in each state, but it does not provide for very accurate comparisons. The differences in production levels and in trends up or down are confusing. The amount of fluctuations, however, can be summarized in a single figure for each state, and direct comparisons can be made by comparing these figures. These summary figures are shown in table 1. They are the standard deviations of the first differences between the data for successive years (which removes the influence of trends) divided by the mean of the original production data (which converts the figures to comparable percentage terms).

TABLE 1. FLUCTUATIONS IN CORN PRODUCTION IN VARIOUS STATES, 1900-1936

(Coefficients of variation based on first differences)

Kansas	Nebraska	Iowa	Illinois	Ohio	United States
31.2	23.8	13.6	14.1	13.3	10.5

[4]Corn prices would be expected to fluctuate most in the marginal states (where crop fluctuations are greatest). Summarizing the price fluctuations in a manner similar to table 1 shows, however, that they do not differ very greatly by states and that the differences are not in all cases directly related to differences in crop fluctuations. The data are given in table 2.

TABLE 2. FLUCTUATIONS IN CORN PRICES IN VARIOUS STATES, 1908-1928, OMITTING 1916-1919

(Coefficients of variation, based on first differences)

Kansas	Nebraska	Iowa	Illinois	Ohio	United States
21.5	24.6	25.7	23.0	22.8	13.5

IMPORTANCE OF CORN AS A FEED CROP

How much would a stabilized supply of corn contribute to stability in the total supply of feed grains in the Corn Belt? In Iowa it is well known that corn is the most important crop, but it is not generally realized how important it is; in actuality, corn accounts for 70 percent of all the feed (other than pasture) produced in Iowa. The great importance of corn is shown in fig. 4 where total feed grain production (the solid line) fluctuates sharply from year to year. The dotted line, showing the fluctuations in total feed grain production with corn production stabilized (at its trend value for each year) is much more stable. Computations show that over the past 36 years 75 percent of the fluctuation in the total feed supply, including hay, in Iowa has been caused by fluctuations in corn production. To put it the other way round—stabilizing corn supplies would remove 75 percent of the fluctuation in total feed supplies.

The picture is similar in the North Central states.[5] Since

[5]This is the name given to the western two-thirds or so of the Corn Belt, plus several states just outside the northwestern border of the Corn Belt. Specifically the North Central states include Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska and Kansas.

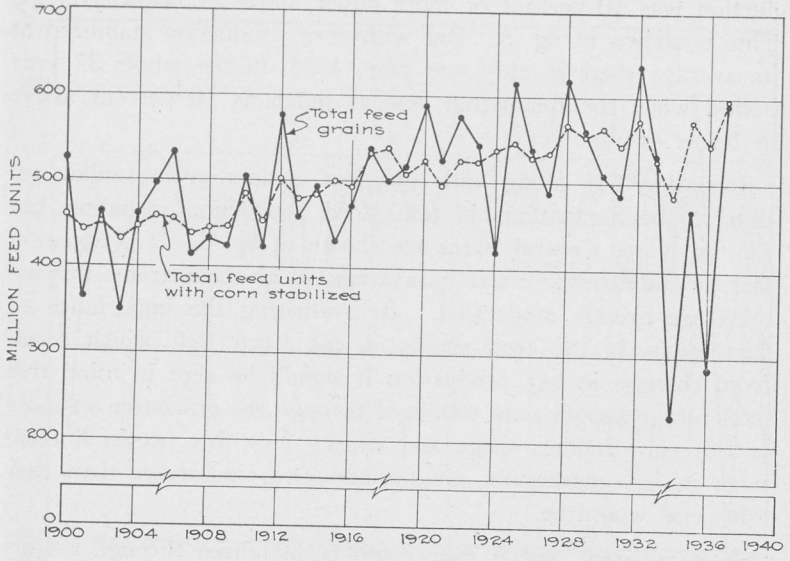

Fig. 4. Total feed grain production in Iowa, with and without corn stabilized, 1900 to 1937.

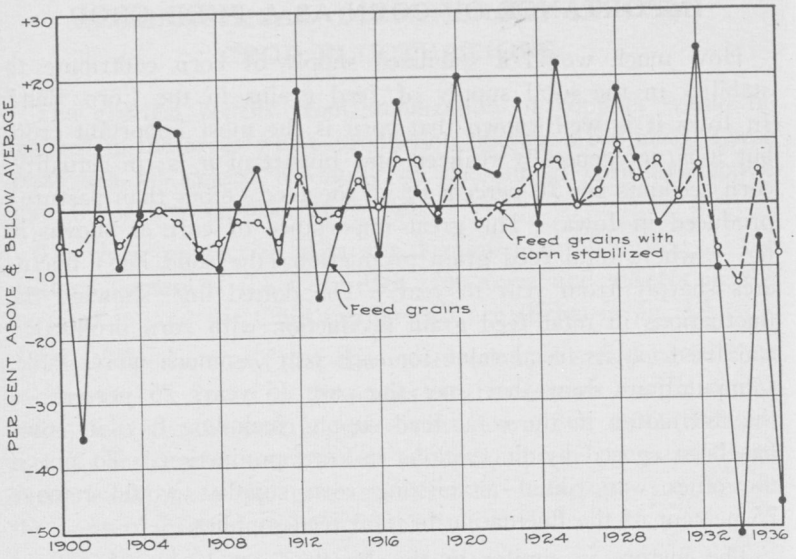

Fig. 5. Total feed grain production in North Central States, with and without corn stabilized, 1900 to 1937.

1900 there have been 14 years when the total feed grain production was 10 percent or more either above or below average. This is shown in fig. 5. But with corn production stabilized at its average there is only one year, 1934, in the whole 37 year period when the fluctuation was as much as 10 percent above or below average.

Including hay along with the feed grains gives similar results. The fluctuations in total feed production including hay for the North Central states are shown in fig. 6. It is apparent that by stabilizing corn at its average all of the extreme fluctuations are greatly moderated. In evaluating the importance of fluctuations in the feed supply in the Corn Belt which result from changes in hay production it should be kept in mind that total forage supplies are stabilized through the utilization of more or less corn fodder, silage and straw. For this reason fluctuations in hay production are probably less important than they otherwise would be.

It is apparent that if corn could be stabilized through a storage program great progress would be made not only toward level-

ing out the supply of feed grains going to meat animals but also the total feed supplies going to all livestock in the Corn Belt.

INDIVIDUAL STORAGE IN THE PAST

Farmers acting individually have in the past carried over a certain amount of corn from one year to the next. The amount of corn thus carried over is shown in bushels each year from 1900 to 1930,[6] in fig. 7A.

The carryover is only a small percentage of the total crop; over the period from 1900 to 1930, it averaged only 3.8 percent of the crop. The amount carried over varied considerably from year to year, however, as fig. 7A shows. In general, the larger the crop the larger the carryover, and conversely. The biggest carryover was 11 percent of an average crop, after the large 1920 crop and the low prices resulting from the post-war depression; the smallest carryover was 1 percent, after the small crop of 1901.

The relation between the size of the corn crop and the size of the carryover from that crop is shown in greater detail in

[6]After 1930 the date was changed from Nov. 1 to Oct. 1. The data after 1930 are therefore not comparable with the data before 1930.

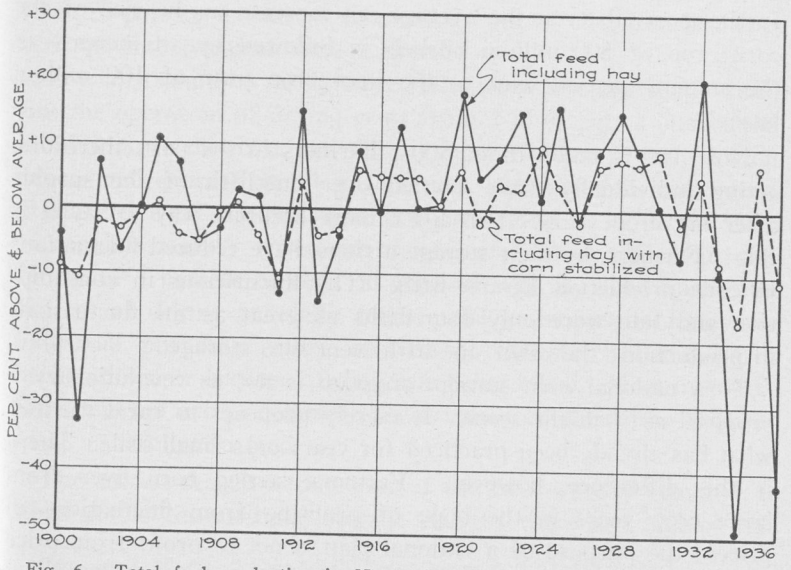

Fig. 6. Total feed production in North Central States, with and without corn stabilized, 1900 to 1937.

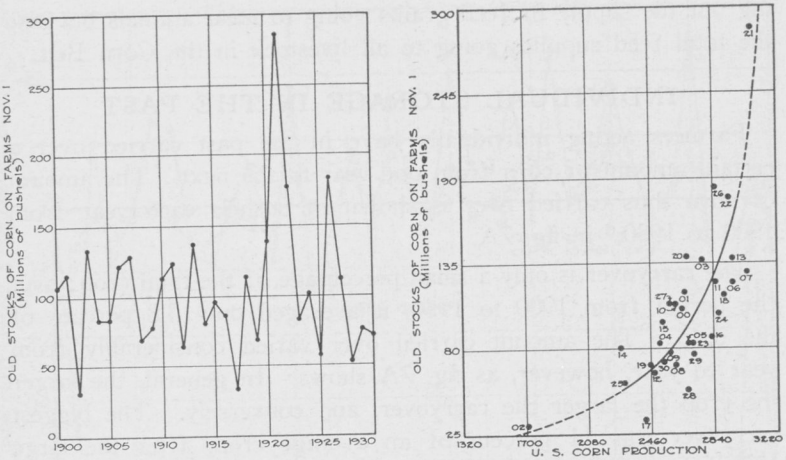

Fig. 7. (A, left—B, right). Old stocks of corn on farms Nov. 1, and corn production, United States, 1900 to 1932.

fig. 7B. In this chart the carryover scale runs up the side and the crop size along the bottom. The dotted extensions of the curved solid line are run out to the extreme years. The chart shows a fairly high positive correlation between the size of the crop and the size of the carryover from that crop. It shows, furthermore, that on the average, an increase in the size of the corn crop of 500 million bushels is followed by an increase in the amount carried over to the next crop year of 100 million bushels.

Now 100 is one-fifth of 500. Farmers in the past, therefore, acting individually, have carried over one-fifth of the surplus after big crop years. Perhaps a more accurate way to say it is this: Farmers, by their storage actions, have reduced fluctuations in corn production by one-fifth. The fluctuations in consumption and sale were only four-fifths as great as the fluctuations in production; the other one-fifth went into storage.

So a national corn storage program is not as revolutionary a proposal as it might seem. It merely proposes to carry further what has already been practiced for years on a small scale. There is this difference, however. Farmers carried corn over from large crop years in the hope of profiting from fluctuations in prices; the purpose of a national plan is not to profit from price fluctuations but to smooth them out.

COSTS OF STORING CORN

In an economic world where everyone knew all about what to do and was free to do it, farmers would carry over corn from big crop years and dump it during small crop years to such an extent that price fluctuations would be greatly reduced. Prices would fluctuate only just enough to cover the costs of storage.

It may be that farmers have been doing just that thing. It may be that any increase in storage operations would smooth price movements out so much that they would not cover storage costs, and the result would be a net loss. Let us see.

The first thing to do is to determine what these storage costs are.

The costs of storage depend in large part upon where the grain is stored. In the past the bulk of the corn was stored right on the farm where it was grown. Under a general storage plan, the bulk of the corn would also be stored on the farm.

There are two or three reasons for this. The first reason is that just after harvest corn contains a high percentage of moisture. The limit of moisture content for safe storage at the terminal elevators is about 17 percent in the winter and 13 percent in the summer. In the early winter Iowa corn ordinarily runs from 18 to 25 percent moisture. It would go out of condition if shelled and put into terminal storage then.[7]

The corn could be safely stored if it were first artificially dried. But the operation of drying costs from 2 to 4 cents a bushel and, in addition to this cost, the shipper bears the loss in weight from drying and general handling. Further, not only does commercial drying drive off the moisture, but (according to industrial users of corn) for every 1 percent of moisture driven off, about one-fourth of 1 percent of corn oil goes off with it. And finally, the process of drying generally renders the grain unsatisfactory for industrial purposes, either because of the starch being partly broken down or because of the germ being killed. Most industrial firms will not accept commercially dried corn; it must be disposed of at a discount to feeders.

The second reason is that even if the corn were dry enough to store at the terminal the storage charges there are higher than

[7]Parts of this section are adapted from Iowa Agr. Expt. Sta., Cir. 113, "When Shall We Sell Our Corn?" 1929, now out of print.

they are on the farm. (The amount of the charges on the farm is given in detail later in this bulletin.) The unloading charge, which also includes 10 days free storage, is 1¼ cents a bushel. The storage charge thereafter is $\frac{1}{20}$ cents a day, nearly 1½ cents a month. Shrinkage is not a factor here, however, since the same number of pounds of corn that were weighed into storage are weighed out.

The third reason is that the most strategic market location for Iowa corn is the farm where it was grown. There is some advantage in having grain in store at the terminal where it can be sold on a bulge at a moment's notice, but grain on the farm in Iowa, surrounded as it is by a ring of markets, is in a position to take advantage of the highest on-track bids from perhaps a half dozen alternative sources at any time. Grain in store at a terminal market has to be sold there (or else bear the cost of shipment to another market), though the original terminal market where it is located may never offer the highest price of all the available markets during the period of storage.

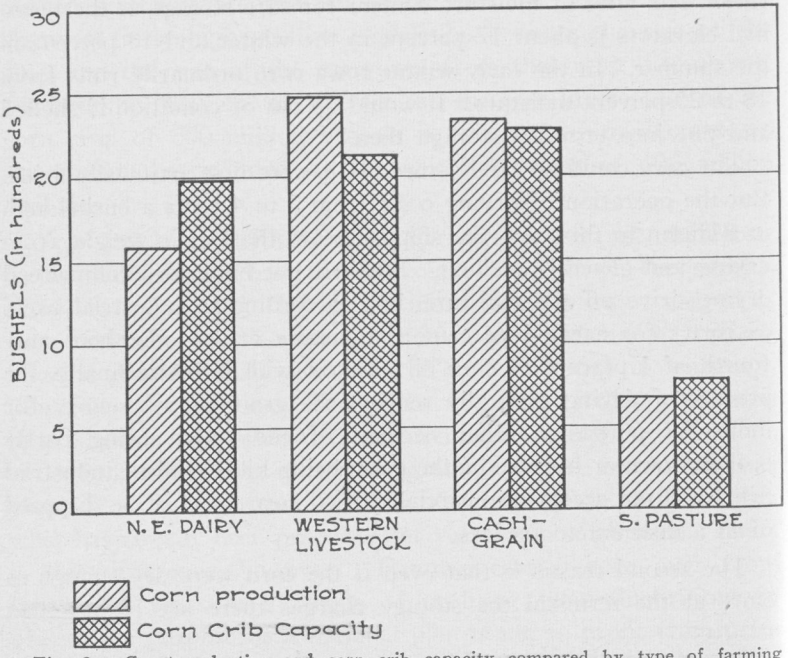

Fig. 8. Corn production and corn crib capacity compared by type of farming areas in Iowa.

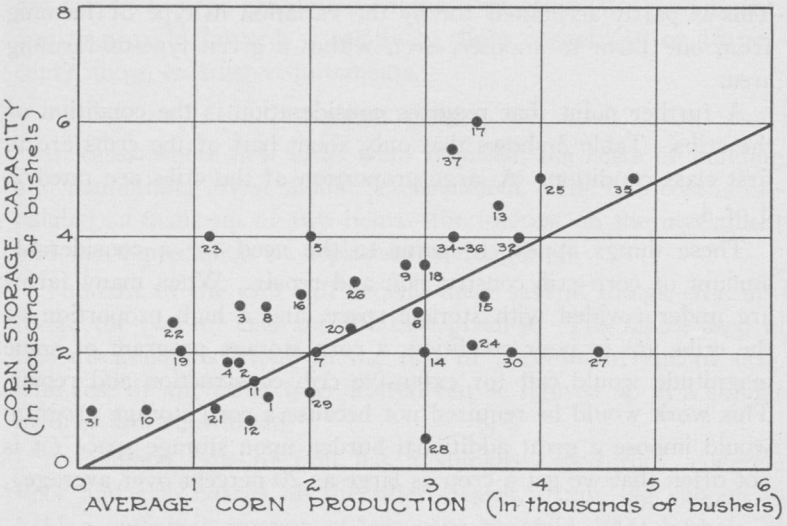

Fig. 9. Relation between corn storage capacity and average corn production by individual farms, cash grain area of Iowa. (Dot numbers are farm serial numbers.)

FARM STORAGE SPACE

We have seen that the best place to store corn is in the crib on the farm where it was grown. The cost of storing corn there depends upon several things. One of the most important is the adequacy of the corn storage space already available on the farm.

A soil conservation survey of 400 representative Iowa farms conducted during 1936 included the question of the amount and condition of corn storage space on farms. This survey showed that in each of the type-of-farming areas of the state the average amount of corn storage on the farm was roughly equal to the average corn production per farm. This is shown in fig. 8. The basic data are given in table 3.

This does not mean that the amount of corn storage on each farm was roughly equal to the average corn production on that farm. Figure 9, where each dot shows the amount of corn storage space and the average corn production for one farm, shows that there is only a rough correlation between the two. The correlation is +0.55. This is for the cash grain area. The situation in the other areas is similar.

Evidently some farms have considerably more storage space than average corn production, while others have considerably less.

This is partly accounted for by the variation in type of farming from one farm to another, even within a given type-of-farming area.

A further point that requires consideration is the condition of the cribs. Table 3 shows that only about half of the cribs are in first class condition. A large proportion of the cribs are rated 2, 3 or 4.

These things appear to point to the need for a considerable amount of corn crib construction and repair. When many farms are underprovided with storage space, and a high proportion of the cribs are in poor condition, a corn storage program of some magnitude would call for extensive crib construction and repair. This work would be required not because a corn storage program would impose a great additional burden upon storage space (it is not often that we get a crop as large as 20 percent over average),

TABLE 3. IOWA CORN STORAGE DATA BY SECTIONS.†

Data	Northeast dairy section	Western livestock section	Cash grain section	Southern pasture section
Total number of farms	171	108	109	117
Average corn crib capacity in bushels (all types together)	1986	2137	2293	776
Tenure:				
Number of owners	87	40	35	51
Number of tenants	73	57	61	41
Number of owners and tenants	11	11	13	25
Average acres per farm	176	189	168	194
Average corn crib capacity in bushels	1568	2454	2319	882
Combined crib and granary*	3310	1696	2010	957
All other types, bushels capacity		454	2709	503
Condition of crib				
Number "good"	21	61	57	54
Number "medium"	52	16	7	7
Number "fair"	49	28	29	61
Number "poor"	17	9	5	2
Present value corn crib	$246.00	$537.00	$513.00	$259.00
Combined crib and granary	$441.00	$596.00	$733.00	$341.00
All other		$1488.00	$800.00	$714.00
Average corn production, 1935 (bushels)	1589	2484	2351	673
Average corn inventory, May 1936 (bushels)	398	377	437	92

†Data for the eastern livestock area were not available in time for this study.
*This figure shows the average corn capacity on those farms which had combined cribs and granaries. Practically no farms had both cribs and combined cribs and granaries.

but to put a large proportion of the corn cribs into good repair, and to provide for only a relatively slight excess (10 or 15 percent) above existing requirements.

CRIB COST

In cases where new cribs were required, the costs of building and maintaining them should be considered. The crib cost is calculated as made up of two items—the interest on the investment and the depreciation or replacement charge.

The cost of the crib will depend upon several things—the material, the type of crib and the care given it. The figure used in this discussion is based on the cost of a common type of crib. The cost of any other type desired can be figured up in a similar manner and substituted.

A common type of crib has a shingled, shed roof, concrete floor and crib boards on the sides. Such a crib, big enough to hold a sufficient amount of ear corn to yield 1000 bushels of shelled corn, would have a floor 8x32 feet, a rear height of 10 feet and a front height of 12 feet. The materials—lumber, cement and gravel—required to build a crib of this size, at present retail prices in Ames, would cost approximately $185. Hardware, paint and labor would bring this figure close to $240. The annual interest on this, figured at 6 percent on half the original value (on the basis of straight-line depreciation), would be $7.20, or .7 cents a bushel per year.[8]

The annual replacement charge, assuming a normal life of 40 years would amount to $6. With the crib filled to capacity (1000 bushels) the replacement charge would then be .6 cents a bushel per year. Finally, the insurance on the crib and corn at mutual rates would amount to about .4 cents a bushel per year. Thus the total annual cost of the crib—interest on investment, depreciation and insurance—amounts to approximately 1.7 cents a bushel. Losses by rats and mice vary from farm to farm and are difficult to estimate in a single figure. If we wish to use round numbers, we may take 2 cents a bushel per year as an approximately correct allowance to cover crib and insurance costs and losses from rodents.

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[8]Anyone interested in detailed plans for corn cribs can secure them by writing to the Agricultural Engineering Section of the Iowa Agricultural Experiment Station, Ames, Iowa.

The "shrink," or loss of moisture of the corn during storage, averages 9 or 10 percent during the first storage season. This loss in weight, however, is approximately offset by the higher price that the corn will command, because the reduction in moisture content raises the grade of the corn.

INTEREST COST

The interest cost on a corn loan, secured by the corn as collateral, would depend upon the amount of the loan per bushel, the rate of interest and the length of time for which the corn would be stored.

The federal government made corn loans in 1933 and 1934 at 45 cents per bushel. In 1935 and 1936 the rate was 55 cents. In 1937 it was set at 50 cents. This figure, 50 cents, may be used as the basis of our calculations.

The federal corn loan rate of interest was 4 percent. If corn were stored for a year, the interest cost on the basis of these figures would be 2 cents per bushel.

TOTAL STORAGE COSTS

Under the most favorable conditions for profitable corn storage—large crops alternating with small crops—the crib would be used every other year. The crib costs are overhead charges that run on whether corn is stored or not. Even under the most favorable conditions then, 2 years' crib costs would be charged to 1 year's storage. The crib cost of storing corn from a large crop to a short crop the next year would therefore be 4 cents per bushel. Added to this would be the 2 cents a bushel interest on the value of the corn stored. The total storage costs for each storage operation would therefore be 6 cents per bushel.

Under actual conditions, as we saw in the early part of this bulletin in fig. 1, corn crops do not alternate between large and small size from year to year. They come irregularly. And the large crops come one and a half times as frequently as small crops, exceeding average size only about half or two-thirds as much as small crops fall short of average size.

This means that, on the average, corn would have to be stored from two large crops in succession.[9] This would be the average

[9]We saw earlier that there are 50 percent more large crops (crops above average size) than small crops (crops below average size). Under a strict definition of average size, therefore, crops would on the average be stored from one and a half large crops in succession. But there would be occasional crops of about average size when grain would be neither stored nor taken out of storage. These would increase the average length of time of grain storage to roughly 2 years.

situation. Quite frequently, of course, there would be only one large crop, followed at once by a small crop, and quite frequently there would be three (or even more) large crops in succession before a short crop happened along. But on the average the surplus would have to be carried for 2 years and then dumped on a short crop year. The crib costs, being incurred every year whether corn was stored or not, would cover 3 years, amounting to 6 cents per bushel. The interest cost would be 1 cent the first year (since the crib would be only half filled) and 2 cents the second year, amounting to 3 cents altogether. The total cost for each storage operation would therefore be 9 cents per bushel.

In both of these situations, the costs of storage per year would be the same. The 6 cents for storing corn every other year would equal 3 cents per year; the 9 cents for storing corn every 3 years would also be 3 cents per year. The total storage costs, therefore, would on the average amount to 3 cents per bushel stored per year.

EFFECT OF SIZE OF CORN CROP UPON HOG SUPPLIES

We have seen that the cost of storing corn averages about 3 cents per bushel stored per year. What now would be the gains from storing corn? Would they be more or less than the costs?

In order to answer this question, we have to consider first what the effects of fluctuations in corn production have been in the past; that will show, in reverse as it were, what the gains would be from smoothing them out.

Only a small percentage of the corn crop is sold as cash grain, about 85 percent of the corn produced in Iowa being fed to livestock in the county where it was grown. The percentage for the Corn Belt as a whole is not far from the same figure. The most important effects of fluctuations in corn production, therefore, are those which show up in the livestock industry.

In Iowa, hogs are the chief source of income to farmers; they bring in over 40 percent of the total income. Cattle come next, contributing about 16 percent.[10] For simplicity, most of our discussion of livestock will run in terms of the largest item, hogs.

[10]Basebook of Iowa, Special Report No. 1, Iowa Agr. Ec. Subsection and Extension Service Cooperating, pp. 9-10, 1936.

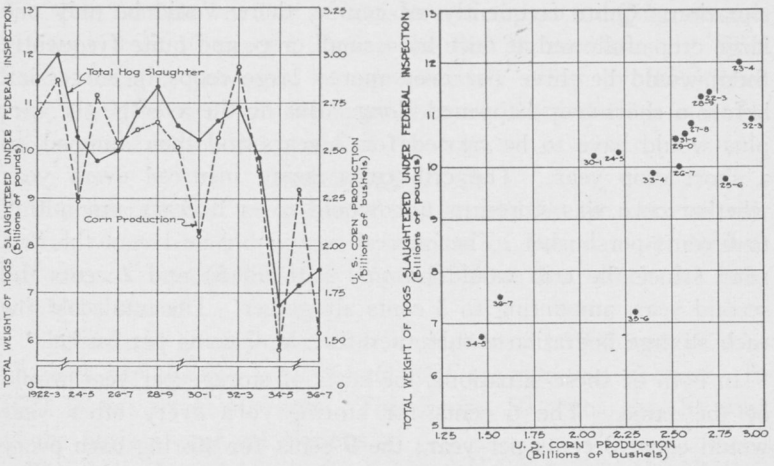

Fig. 10. (A, left—B, right). Corn production and total weight of hogs slaughtered under federal inspection, United States, 1922 to 1936.

The effect of fluctuations in corn production upon hog production is shown directly in fig. 10. This figure shows total corn production in the United States each year since 1921 and the total pounds of hogs slaughtered under federal inspection in the hog year beginning Oct. 1 of the same year.

In this chart, as in the other charts that follow, the data are plotted in two different ways in the two different sections of the chart. The simplest way is used in the first section (section A). A somewhat more technical, but often more illuminating way, is used in the second section (section B). In section A the data are plotted in the form of a time chart. One scale runs up one side, the other scale runs up the other side, and time runs along the bottom. In section B, the same data are plotted in a scatter-diagram. The scale for one of the series runs up the side, but the scale for the other series runs along the bottom. Time is shown by the date written beside each dot. A scatter diagram of this sort makes some features of the data clearer than a time chart.

The two series—corn production and hog slaughter—show a general tendency to move together. The correspondence in movement, however, is not at all complete. Decreases in corn production are followed at once by decreases in hog slaughter, but marked increases in corn production take more than a year to show up in hog slaughter.

The reason for this is clear. Farmers can reduce the total weight of their hog slaughter very quickly when the corn crop is small, as it was in 1924 and 1934. But once the hogs are gone, and a big crop comes along, hog slaughter cannot snap back to full capacity at once; it takes more than a year to build up the herd again. This is particularly true if the increases are large. A small increase in corn production will be taken care of by feeding hogs to heavier weights, but a large increase can only be taken care of by heavier breeding, which cannot show up until the next hog crop year.

How can this be taken into account in our charts? One way would be to lag the hog slaughter series a year after the corn production series. But this would shift the whole series, whereas it is only the years of large increases in corn production that need to be dealt with. And it would ignore the size of the current corn crop each year. What is needed is to identify the years when large increases took place in corn production, and in those years only, to average up the large crop with its predecessor.[11] We may define a large increase as one over 10 percent. There are 4 such years—1925, 1931, 1932 and 1935.

The effect of handling the corn production data in this manner for these 4 years is shown in fig. 11. The commanding in-

[11] A weighted average is used, giving the preceding year twice the weight of the current year.

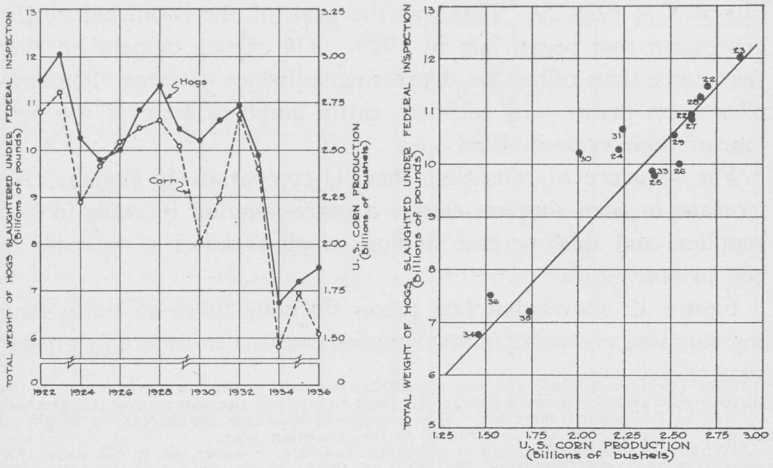

Fig. 11. (A, left—B, right). Corn production and total weight of hogs slaughtered under federal inspection, United States, 1922 to 1936. Large corn crops averaged with preceding crops.

fluence of corn production upon hogs slaughtered is clearly shown in section A.

Section B shows the same thing, the closeness of the relation being indicated by the closeness with which the dots lie along the sloping line drawn through them.[12] The chart shows furthermore that a change in corn production of 250 million bushels is associated with a change in the total weight of hogs slaughtered of 10 billion pounds. These quantities represent about 10 percent in both cases. The relationship, therefore, is 1 to 1—a change in corn production results in an equal percentage change in hog supplies.

EFFECT OF SIZE OF HOG CROP UPON HOG PRICES

We are now ready to consider the next link in the chain of cause and effect.

The changes in hog supplies shown in fig. 11. in turn cause marked changes in the opposite direction in hog prices. This effect is definite and clear-cut during periods when the demand for hogs is stable.[13]

The demand during the period from 1922 to 1929 was reasonably stable. The hog supplies and prices each year from 1922 to 1929, inclusive, are shown in fig. 12. The inverse correlation between hog supplies and prices is clearly shown. The only year when a change in supplies did not result in an opposite change in prices is 1928-29. This was the peak of the boom before the depression that began late in 1929. The strong demand in that year more than offset the depressing influence of larger hog supplies upon prices. In addition, cattle numbers were at the bottom of their cycle in 1928.

The sequence of causation, then, is comparatively simple: An increase in corn supplies causes a corresponding increase in hog supplies, and this increase in hog supplies causes a decrease in hog prices.

Figure 12 shows that hog prices fluctuate more violently than hog supplies. A change in hog supplies causes a considerable greater

[12]One could go further, and use a weighted average of the corn production in the current year and the preceding year for years of marked decreases (over 10 percent) as well as for marked increases. The average in this case should give a weight of about 2 to the current year, instead of to the preceding year.

[13]When the demand for hogs is changing violently, however, as it did from 1930 onward through the depression, the effect of these changes in hog demand partially obscures the effect of changes in hog supply. Hog supplies push hog prices up or down the same as ever, but the push is (more or less) offset or added to by the effect of changes in demand.

change in hog prices. Figure 12B shows more clearly than fig. 12A that the change in hog prices is nearly twice as great as the change in hog supplies that caused it. The chart shows that a change in hog slaughter of 1 billion pounds causes a rise in hog prices of nearly $2 per 100 pounds. This can be stated in percentage terms: A change of 10 percent in hog supplies, for example, causes an opposite change in prices of nearly 20 percent.

If the relationship were 1 to 1—if a change of 10 percent in hog supplies caused an opposite change in hog prices of an equal amount (10 percent)—the change in the one would approximately offset the change in the other, and the total income would remain roughly constant, unaffected by changes in supplies.

But, as fig. 12 shows, the change in hog prices is nearly twice as great as the changes in hog supplies that caused it. The total income, therefore, fluctuates with (or rather, conversely with) hog supplies. The effect upon the total income can be shown by taking the original data for a few representative large and small crop years.

The corn crop in 1923, for example, was large; it amounted to 2.9 billion bushels. The total weight of hogs slaughtered in the hog year October 1923 to September 1924 was correspondingly large; it totaled 12 billion pounds. The price of hogs was correspondingly low, only $7.41 per 100 pounds live weight. The

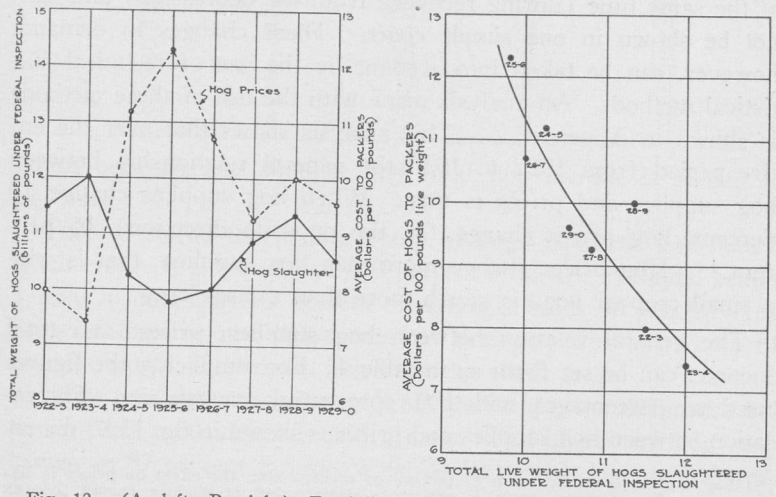

Fig. 12. (A, left—B, right). Total live weight of hogs slaughtered under federal inspection, and average hog prices, United States, 1922 to 1930.

total income from the sale of hogs, therefore, was 12 billion multiplied by $7.41/100, which equals **889 million dollars.**

Then came the short corn crop of 1924. Because the crop was small, the price of corn was high, and heavy liquidation of unfinished hogs resulted late in 1924. Hog slaughter for the 1924-25 hog year was reduced to 10.3 billion pounds which sold at a price of $11.18. The total income from this small hog crop was 10.3 billion multiplied by $11.18/100 which equals **1,151 million dollars.** The total income from the small hog crop was materially higher than the total income from the preceding year's large hog crop.

This sounds strange, indeed, almost perverted. But that is the case with most staple foods. If they are scarce, people will pay high prices rather than turn to something else. Economists summarize this sort of situation in a phrase by saying that the demand is inelastic.

EFFECT OF SIZE OF HOG CROP UPON THE TOTAL VALUE OF THE CROP

The corn crops in 1934 and 1936 were still smaller than the crop in 1924. They showed up in severe reductions of hog supplies. The effects of these reduced hog supplies upon hog prices were complicated by the changes in demand that were taking place at the same time (during recovery from the depression) and cannot be shown in one simple chart. These changes in demand, however, can be taken into account by the use of technical statistical methods. An analysis made with the use of these methods is shown in Appendix A. This analysis shows that over the entire period from 1922 to 1936 the general relationship between hog supplies and prices is this: When hog supplies change 10 percent, hog prices change (in the opposite direction) 16 percent.[14] Hog prices change more than hog supplies; that is why a small crop of hogs is worth more than a large crop.

The general relation between hog supplies, prices, and total income, can be set forth as in table 4. For simplicity, the figures used are percentages, with 100 representing average size. The relation between hog supplies and prices is shown in fig. 13A; the re-

[14]For hog crops smaller than 80 percent of average size, the effect on prices is less than this. The demand curve is not quite straight but is slightly curved, convex upwards.

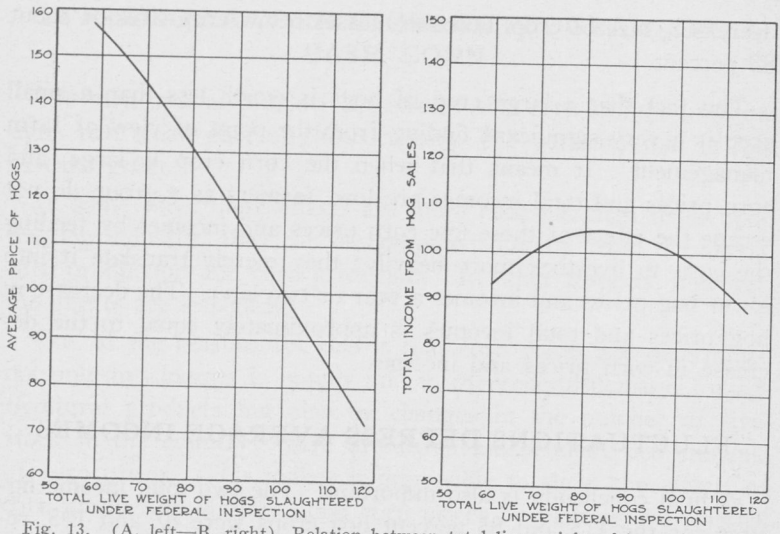

Fig. 13. (A, left—B, right). Relation between total live weight of hogs slaughtered under federal inspection, average hog prices and total income from hogs.

TABLE 4. RELATION BETWEEN HOG SUPPLIES, PRICES AND TOTAL INCOME.

(All figures in percent of average, 1921-1931)

Hog supply	Hog price	Total income
65	150	97
70	144	101
75	138	103
80	131	105
85	124	105
90	116	104
95	108	103
100	100	100
105	92	97
110	84	92
115	76	87

lation between hog supplies and total hog income is shown in fig. 13B.

Table 4 shows that a large crop of hogs is worth less than a small crop. It shows that a 110 percent crop, for example, brings a total income only 92 percent of average, but a 90 percent crop brings a total income 104 percent of average. The large crop of hogs is worth 12 percent less than the small crop.

If we consider still larger and smaller crops, the difference between their total values is still greater. A 115 percent hog crop brings an 87 percent income, which is 18 percent less than the income from an 85 percent crop. The rise in total income with

decreasing size of crop, however, ceases below crop sizes of about 83 percent.

The fact that a large crop of hogs is worth less than a small crop is a very significant finding from the point of view of farm management. It means that when the corn crop is large, and corn prices and total incomes are low, farmers as a group do not escape the effect of these low corn prices and incomes by feeding the corn to livestock more heavily; they merely translate it into lower hog prices and incomes a year or two later. The decrease in hog prices and total incomes is approximately equal to the decrease in corn prices and incomes.

FLUCTUATIONS DEPRESS AVERAGE INCOMES

A final conclusion is also important. The two total income figures for the 115 and 85 percent hog crops were 87 and 105, respectively. Now if you add up these two total income figures and divide by 2 you get less than 100; you get only 96. That is, the total income from the sale of two hog crops, one of them large and the other small, averages less than the income from two average size crops. Fluctuations in hog supplies not only unstabilize hog sale incomes; in addition, they reduce them. The total income from a series of large, average and small hog crops is less than the total income from a series of average size hog crops.[15]

A national storage program for corn, therefore, that would convert large and small hog crops into a series of average sized crops, would not only stabilize hog prices and hog sales incomes; over a period of years it would raise hog incomes as well. The increase would be slight (only 2 percent) for fluctuations in hog crops of 10 percent above and below average. But for fluctuations of 15 percent above and below average the increase would be 4 percent, and for fluctuations of 20 percent the increase would be 7 percent or more.

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[15]This results from the fact that the line in fig. 13B is curved, convex upwards. If it were straight, the total value of two average sized crops would be the same as the total value of a large and small crop, and smoothing out supplies would not increase total income. If the curve were concave upwards, smoothing out supplies would reduce total incomes. For discussion of this point on a broader basis see Waugh, F. V., Burtis, E. L. and Wolf, A. F., "The Controlled Distribution of a Crop Among Independent Markets," Quarterly Journal of Economics, November 1936.

EFFECT OF A CORN STORAGE PROGRAM UPON CASH CORN

We turn now to consider the effects of a corn storage program upon that small part of the corn crop (15 percent) that is sold as cash grain.

In some ways these effects are more clear-cut than those upon the hog industry; they can be computed directly from the annual corn production and corn price data. In other respects, however, the effects are less clear.

One of the reasons for this is that corn prices are determined not only by changes in supply and in the general demand for agricultural products but also by changes in the number of livestock in the country; there are three independent determinants of corn prices. This makes it impossible to show the effects of corn production directly upon corn prices by plotting the original data in a simple chart, even for the comparatively stable period from 1922 to 1929 that was used in fig. 12 to show the relation between hog supplies and prices. This difficulty, however, is purely statistical. It is taken care of in the statistical analysis of the factors determining corn prices, given in Appendix B. The relation between corn supplies and prices revealed by this analysis is very similar to the relation between hog supplies and prices that was shown in fig. 13.

This means that in the case of corn, as in the case of hogs, a small crop is worth more than a large crop. The number of bushels is less, but the price is so much higher that the result is a higher total value than that of a large crop. This is true for crops down to about 83 percent of the average.

In the case of hogs, we multiplied the total slaughter by the average price, each year, to get the total income. In the case of corn, however, we cannot do this; all the hogs slaughtered are sold as hogs, but only a small percentage of the corn produced is sold as cash corn. This is the other respect in which the effect of corn supplies on corn prices is less clear-cut than the effect of hog supplies on prices. The difficulty here is not statistical; it is conceptual. The total value figures for corn, obtained by multiplying the production by the December price, do not show total sales income, but only imputed total value.

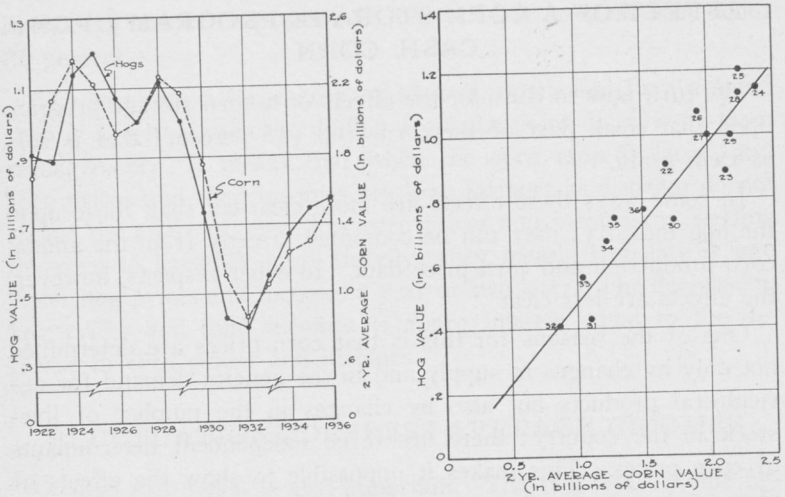

Fig. 14. (A, left—B, right). Total value of corn crop and total value of hog crop, United States, 1922 to 1936.

There are two ways of thinking this thing through accurately. One is to note that the percentage of the corn crop that is sold as corn is fairly constant from year to year, for the state of Iowa[16] and presumably for other parts of the Corn Belt, too. One would be on reasonably safe ground, then, if he multiplied the price of corn each year, not by total corn production, but by 15 percent of the total production. That would show approximately the total income from cash corn sales each year.

The other way of thinking through this situation is to consider that although the bulk of the corn crop is not sold as corn, the corn crop as a whole for the average farmer has approximately the same value whether it is all fed to livestock or all sold as corn. This must be true, since if at any time corn was worth more as cash corn than its imputed value if fed to livestock, farmers would sell more and feed less; and this would bring cash corn prices down to equality with the imputed value of corn fed to livestock.

This is not theorizing; it is a fact. The total value of the corn crop fluctuates closely in accordance with the actual value of the hogs to which it is fed. This is shown in fig 14A, where the total

[16]Bentley, R. C., Destination of Iowa's Commercial Corn. Iowa Agr. Exp. Sta., Bul. 318, p. 6, table 1. 1935.

value (production times price) of the corn crop is plotted with the total value (slaughter times price) of the corresponding hog crop.[17]

Both of these series show the effects of the depression after 1929. Indeed, part of the positive correlation between them results from the similarity of their responses to the depression. In order to remove these depression effects, both series should be divided through by an index of demand. The index of total non-agricultural income for the United States is used for this purpose. The results of dividing the items in each series by the corresponding index of demand each year[18] is shown in fig. 15.

It will be observed that the line in fig. 14B (and in fig. 15B also) which represents the relationship of corn values and hog values, has a slope of about 1 to 1. This means that the changes in corn crop and hog crop values are not only closely related, they

[17]The corn crop values are given in Agricultural Statistics, 1937, p. 39, in the columns headed "Farm value." A two year moving average of the value figures is used; that is, each total corn value item plotted in fig. 14 is the average of the current and preceding year. It is a weighted average; the preceding year is given a weight of two, and the present year a weight of one.

The hog crop values are computed by multiplying the total live weight of the hogs slaughtered each month by the average cost of packers for that month, and adding up the twelve products October to September for each hog year. These data are given in "Livestock, Meats and Wool Market Statistics," 1937, pp. 164-165.

[18]The analysis in Appendix A shows that this index of demand does not have a 1 to 1, nor even a constant, relationship to hog prices. Accordingly, the division is performed, not by the index, but by the effect which that index has upon hog prices. If in a certain year the index stood at 90, one would read up from 90 on the horizontal scale in Appendix A, fig 19A, to the curved line, then across from that point on that line to the left hand scale, and divide by that figure .

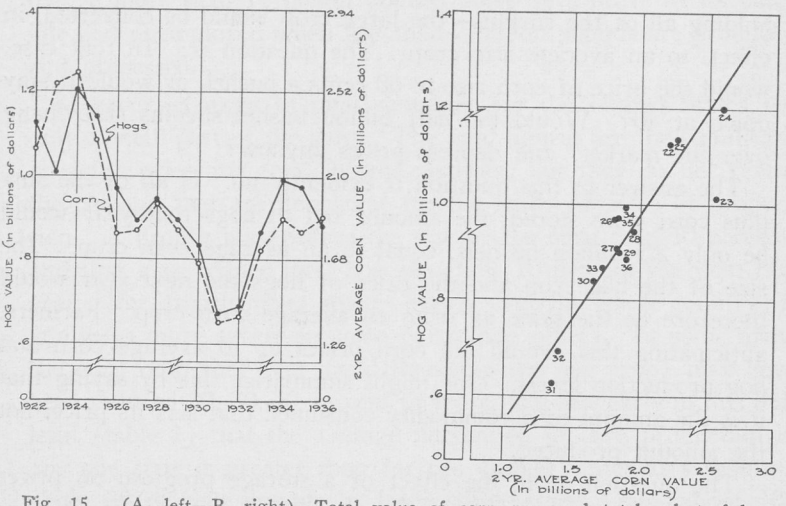

Fig. 15. (A, left—B, right). Total value of corn crop and total value of hog crop, United States, 1922 to 1934. Both corrected by same index of demand.

are also approximately equal in amount. A 10 percent change in corn crop values is associated with a 10 percent change in hog crop values, a 20 percent change in corn crop values with a 20 percent change in hog crop values and so on.

WOULD A CORN STORAGE PROGRAM STABILIZE CORN PRICES?

We have shown the effects of fluctuations in corn production. The question now arises: Would a national storage program smooth them out? If a large crop were reduced to average size by withholding of the surplus, would the price rise to average crop size levels, or would it remain depressed by the fact that the surplus corn was still in existence?

Let us use concrete figures. Suppose that the demand for corn stood at a level such that an average size corn crop of 2.5 billion bushels sold for 60 cents per bushel at the farm. Under these conditions, a bumper crop of 3 billion bushels (20 percent oversize) would depress the price to 40 cents a bushel.

Suppose then that a corn storage program were put into effect, and that it was decided to store all of the surplus (the amount above an average crop). If there were no uncertainty as to the practicability of the program—if people in general expected the administrators to carry through their announced intention of withholding all of the surplus—the large crop would be converted, in effect, to an average size crop. The question is: In that case, would the price of corn rise to 60 cents a bushel, or would it stay down at 40? Would the half billion bushel surplus still "hang over the market" and depress prices anyhow?

The answer to this question is evidently no. If all of the surplus corn were stored, the amount fed to hogs that year would be only 2.5 billion bushels, equal to an average corn crop. The size of the hog crop and the price of hogs the next year would therefore be the same as from an average corn crop. Farmers, anticipating this, would bid corn prices up to average corn and hog production levels. One might summarize this by saying that it is the amount of a commodity consumed that sets its price, not the amount produced.

The question as to the effect of a storage program on prices would be chiefly academic if the program were put into effect, as

it has been in past years, by means of loans at a definite fixed figure per bushel above the natural market price for a large crop. Then the mechanism would work the opposite from normal. Instead of the amount consumed determining the price, the loan value would set the price, and that would determine the amount consumed. If the intention of the administrators were to stabilize the price at 60 cents, instead of deciding to store half a billion bushels from the large crop and trusting that that would raise the price to 60 cents, they would reverse the process. They would set the loan value at 60 cents and expect that that would result in the storage (i. e., the non-sale) of a half billion bushels.

HOG PRODUCTION COSTS ARE INCREASED BY FLUCTUATING CORN SUPPLIES

We have been discussing the effects of fluctuations in corn production upon corn and hog prices and total incomes. We turn now to consider their effects upon livestock production costs.

During the past 10 years, the total weight of hogs slaughtered annually has varied from 11.3 billion pounds in 1928-29 to 6.7 billion pounds in 1934-35. These annual variations in hog production increase both the cost of hog production on the farm and the cost of transporting, processing and distributing the pork. A farm, transportation and processing plant that is equipped to handle more than 11 billion pounds must have many of its parts idle and unemployed when less than 7 billion pounds are produced and processed.

Morever, changes in total slaughter for the United States tell only a small part of the story. The total figures are the significant ones for price and total income analysis; but they do not reveal the changes that are important for the study of costs of production. A drouth may reduce the size of the corn crop 10 percent, and that may reduce total hog slaughter 10 percent the next hog year. But drouth never strikes evenly over the whole country; it is always more severe in some parts than others. In some areas the corn crop that year (and therefore the hog crop) may have been reduced 20, 30, 40 percent or more. We saw early in this bulletin (table 1) that the average fluctuation in corn production in any one state is greater than for the United States as a whole—about 30 percent greater in Iowa, Illinois and Ohio, about 100

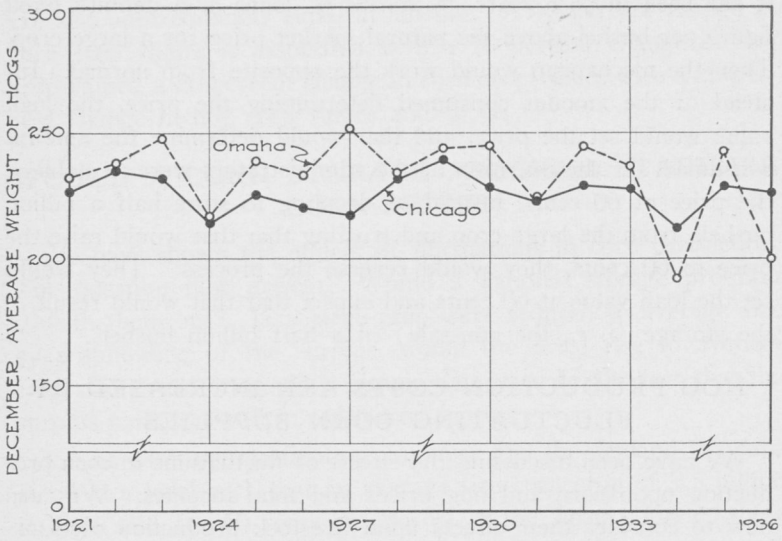

Fig. 16. December average weight of hogs at Chicago and at Omaha, 1922 to 1936.

percent greater in Nebraska and 200 percent greater in Kansas.

The corn production figures for 1937 are illuminating on this point. Corn production for the United States as a whole is a little higher than average. But the state of Kansas has only one-fourth of an average crop, and Nebraska has only one-third of a crop.

What about the distributing system for corn? If supplies are short in one state but plentiful in another state (adjacent or not far away) does not corn flow automatically from surplus to deficit areas, as a result of the differences in prices between the two?

A certain amount of corn does flow in this manner but apparently only enough to alleviate the differences in supplies to a small extent, not enough to remove them. Corn supplies are quickly reflected in average weight of hogs marketed. The figures for Omaha, which serves an area of variable corn crops, and Chicago, which draws from a wider and more stable territory, are illuminating. They are shown in fig. 16. They show that the flow of corn to short crop areas is so inadequate to even out supplies that great differences still exist between the average weights, year by year, in the two markets.

The same situation is revealed by the statistics for Iowa. Figure 17 shows the number of hogs 9 months old and over assessed from 1929-1937 in 21 southern Iowa counties. These counties suffered a serious drouth in both 1934 and 1936. In January 1937 hog numbers were less than one-third of what they had been 3 to 5 years earlier. A study of 41 of the better livestock farmers in better than average financial positions in this area shows that they produced only 55 percent as many hundredweights of hogs in 1937-38 as they had produced in 1932-33.

EFFECT OF FIXED COSTS

Hog production costs are divided on a percentage basis about as follows: feed 75 to 85 percent, other costs (such as veterinary which vary directly with the number of hogs produced) 5 to 10 percent, fixed costs such as interest on buildings and equipment, 10 to 15 percent.[19] If the hog producing plant is equipped to produce 10 billion pounds but is utilized to produce only 8 billion pounds, the cost per pound will be raised by about 3 percent, because the total overhead costs run on as large as ever, but are spread over fewer hogs. Costs per pound go up proportionately more as the hog crop decreases, until the excessive overhead costs

[19]Hopkins, John A. Why Hog Profits Vary. Ia. Agr. Exp. Sta., Bul. 255, 1929.

Fig. 17. Number of swine 9 months old and over assessed in 21 southern Iowa counties, 1929 to 1937.

on a crop half as large as normal in any area result in 10 to 15 percent higher costs per pound than hog crops that fully utilized the fixed investment in the hog producing plant.

With the production of corn only one-fourth or one-third of normal in Kansas and Nebraska in 1937, the inevitably small crop of hogs marketed from these states will have to carry unusually high overhead costs. On the other hand in large hog crop years, such as 1928-29, when 11.3 billion pounds of hogs were marketed, the capacity of the existing plant must have been overtaxed and much overtaxed in the areas of heaviest production. No doubt more than the usual number of sows farrowed in inadequate quarters, excessive crowding resulted from too many pigs and too few troughs in a good many cases, and the same old hog pasture carried a few more pigs than normal—these all resulting in higher than average costs. There is no basis for estimating how much higher costs are in large crop years; much depends upon the weather at farrowing time, the pasture growing season and the fall and winter weather at fattening time. Probably hog production costs over the past 15 or 20 years have been 2 or 3 percent higher due to this variation in use made of overhead, than they would have been had the same total volume of hog production taken place in a series of average sized crops.

HOG WEIGHTS AFFECT FEED-CONVERTING EFFICIENCY

Fluctuations in the corn-hog price ratio have another indirect effect on hog production costs. A given quantity of feed will make more pounds of pork if fed to hogs which are slaughtered at from 200 to 230 pounds than if fed to hogs which are marketed at either lighter or heavier weights. But when the corn prices are low relative to hog prices because of a large crop (or for any other reason), as in the fall and winter of 1937-38, hog producers find it profitable to feed their hogs to heavier weights. Although it takes 10 to 15 percent more feed to put a pound of gain on hogs weighing 250 to 350 pounds than on pigs weighing 175 to 225 pounds, farmers believe they can still increase their profits by using cheap corn to obtain these relatively expensive gains.[20]

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[20]Hogan and others, The Relation of Feed Consumed to Protein and Energy Retention, Mo., Agr. Exp. Sta., Res. Bul. 73, 1925. Robinson, W. L., Effect of Age of Pigs on Rate and Economy of Gains, Ohio Agr. Exp. Sta., Bul. 335, 1919.

They believe it better to take a 10 to 15 percent loss in feeding efficiency than a 20 or 40 percent reduction in corn price.

Unfortunately, no statistics are available to serve as a basis for estimating the amount by which average hog production costs are raised by feeding hogs to heavy weights. But hogs are certainly fed to heavy weights when the corn-hog ratio is favorable. In 1931, a year of fairly favorable hog prices, four cooperative shipping associations in northern Iowa handled 39,000 butcher hogs of which 30 percent weighed over 250 pounds.[21] In years of unusually large corn crops the percentage would be even higher.

On the other hand, every year a small proportion of the hog crop is marketed before the pigs have gained sufficient weight and finish to make first-class meat. In 1931 this class of pigs made up a little over 6 percent of the total number of hogs handled by the four cooperative associations named above. In years when the corn crop is small relative to the number of hogs on hand as in 1924, 1934 and 1936, the percentage of unfinished pigs sent to market increases. This was particularly true at the Omaha market in 1934 and 1936, when the average weight of hogs received at Omaha in December was only 192 and 200 pounds, respectively. The November 26, 1936, weekly livestock report for the Chicago market indicates this situation also in the following quotation:

> "If receipts carried a few more finished butchers and a smaller number of light lights and pigs the Chicago supplies would be more nearly normal for this season."

Every year a few of the hogs are marketed at less than optimum weights and a fairly large number at more than optimum weights. Areas most distant from the meat-consuming centers such as the western Corn Belt normally carry their hogs to heavier weights than those more centrally located. But such estimates as we are able to make indicate that average or total hog production costs could be lowered appreciably if corn and hog production and prices could be stabilized and the main economic incentive for abnormally light and extra heavy market weights removed.

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[21]Thompson, Sam H. and Miller, Paul L. A Method of Analyzing the Effectiveness of Local Livestock Cooperatives in Selling Hogs. Ia. Agr. Exp. Sta., Res. Bul. 193, table 1. 1936.

FLUCTUATIONS IN THE PRODUCTION OF OTHER KINDS OF LIVESTOCK

Hogs and corn are an almost inseparable combination in the Corn Belt, as we have seen; but fluctuating corn supplies affect the other kinds of livestock as well, only somewhat less directly. Figure 18 shows the number of cows and of all other cattle assessed in 21 counties in southern Iowa 1929 to 1937. It is evident that the recent drouths, severe as they were, had little influence on the number of cows kept; but they did cause a liquidation of a part of the other cattle. Similar data for sheep indicate that their numbers were well maintained in the recent drouth years.

Data on the numbers of animals on farms are misleading, however, as an index to the stability of the particular livestock enterprise. On 41 identical farms in southern Iowa the total cattle on hand May 1, 1937, was only 69 percent of the number on hand at that time in 1932 and 1933, but what is more striking, the total hundredweight of beef produced in 1936-37 was only 55 percent of the production in 1932-33. In other words, the cattle were carried through on maintenance rations, and satisfactory gains on the young cattle were not obtained. There was an almost complete absence of fattening operations in this latter period. While these data cover two of the most severe drouths in the his-

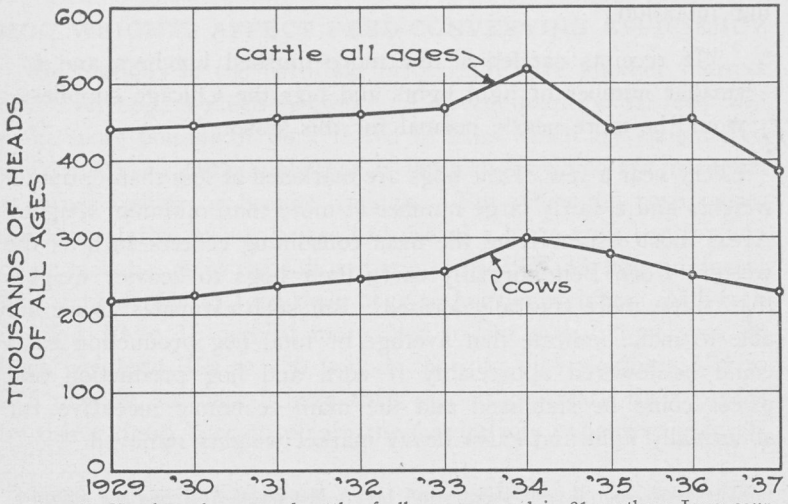

Fig. 18. Number of cows and cattle of all ages assessed in 21 southern Iowa counties, 1929 to 1937.

tory of farming in the state, they illustrate the adjustment which takes place between the cattle and corn supplies in times of less severe fluctuations.

The keeping of cattle on maintenance rations which do not result in normal growth and development not only results in lower output of beef for a given investment, but such practices definitely increase the feed requirements per pound of gain. Feed costs are 10 to 15 percent higher per pound of gain on yearlings than on calves and 25 to 30 percent higher on two-year old.[22] Thus a retardation in the normal age of marketing means higher costs.

In the cattle fattening enterprise, the relationship between corn production and the ratio of fat cattle prices and corn prices is not as direct as in the case of hogs. Only a part of the cattle going to market are corn fattened, and changes in demand as well as in the proportion of finished cattle going to market often result in considerable variations in the profits of fattening cattle, independent of corn supplies. Nevertheless, changes in corn production and prices are one of the most important factors causing changes in the number of cattle put into Corn Belt feed lots.

Fluctuations in corn production have other important effects. Unusually low corn prices and a high prospective "margin" for fat cattle attracts inexperienced cattle feeders to make investments in the business and undertake a job in which they are less efficient than the experienced feeders.

The history of fattening cattle in the Corn Belt is one of alternate years or series of years of profits and losses. Often times a short corn crop causes too many feeders to cease operations, with the result that abnormal profits are made on fat cattle. Then when a normal corn crop is harvested and corn prices have fallen, too many cattle are put on feed. Under such fluctuating profit ratios, efficiency in the use of feed is only one of a number of considerations. Although it takes twice as much feed to put on the gains that make cattle "very fat" as compared with the gains obtained earlier in the feeding period, many cattle were kept in the feed lot for an additional one to three months in the hopes of hitting a better market when the prices for fat cattle went off in the spring of 1936. Thus, we find that fluctuating corn supplies lead to incomplete utilization of the investment in livestock

[22]Morrison, F. B. Feeds and Feeding, 20th ed. (1936) p. 643.

shelter, equipment and labor and in many cases to an inefficient use of feed.

Other social advantages flowing from a stabilization of meat production would be greater stability in other livestock enterprises, such as dairying and poultry and egg production, a more constant flow of all livestock products through the marketing and processing channels to the consumer and the lowering of risks all along the line. This latter factor, the economic risk which is associated with modern agricultural production, has become one of the chief concerns of the present administration. While not measurable in economic terms, it is important; each reader will best make his own evaluation of how important it is when summing up the favorable and unfavorable factors.

But if these gains are to flow from a stabilization of corn supplies, it should be reemphasized that not only must the supply of corn be so stabilized that it will smooth out total United States corn supplies, or central market, or United States average corn prices—it must smooth out supplies and prices area by area. A simple program like the recent corn loans is only a beginning step in the stabilization of Corn Belt agriculture. Something more nearly akin to a crop insurance program would appear to be necessary.

Perhaps no administratively feasible program can be worked out that would completely stabilize corn supplies and prices in each area. It is indeed doubtful if complete stabilization would be desirable, even though attainable, especially in view of the fluctuations in other sections of national economic life. Much might be accomplished, however, by a vigorous educational program pointing out the advantages to the producers of stabilizing their livestock production programs and storing the excess corn in good years; this coupled with an effective production credit program adapted to the needs of the various areas should make possible the attainment of much greater stability than now exists.

COSTS AND BENEFITS SUMMARIZED

We reached the conclusion, in the section dealing with the costs of storing corn, that storage costs would equal 3 cents per bushel of corn stored, per year. The biggest crops we have ever produced have been about 3 billion bushels. This is 20 percent

larger than average. These very large crops come only about once every 10 years. More frequently, we get moderately large crops, about 10 percent oversize. Sometimes two or three of these come together. Sizing up the situation, we may say that a full-fledged stabilization program should provide for storing as much as 20 percent of the crop.

The cost of 3 cents per bushel for 20 percent of the crop would be equal to only $^3/_5$ of a cent per bushel on the whole crop. If a farm that normally produces 5000 bushels of corn, in a good year produces 6000 bushels and stores 20 percent (1000 bushels), of its average production, the total storage cost at 3 cents per bushel would be $30 a year. This would be only $^3/_5$ of a cent per bushel produced.

In other words, it appears that livestock producers and others would have to pay less than 1 cent a bushel more than they now do in order to cover the additional costs of having a stable instead of a fluctuating supply of corn. Would the benefits exceed this additional cost?

The benefits may be enumerated in the order in which they were discussed. (1) Livestock production, prices, and total income would be stabilized. The value of this stabilization cannot be measured in dollars and cents, but with our present highly commercialized farming and heavy fixed costs, it is without question one of the more important benefits. (2) Total income from hog and cash corn production would be raised slightly, in the neighborhood of 1 percent. (This increase in income alone would more than offset the costs of storage of the excess corn supplies—assuming no change in demand). (3) Hog production costs would be lowered by a small amount (2 to 3 percent) through a more complete utilization of overhead costs and perhaps that much more through the adjustment of feeding operations so that a larger percentage of the hogs would be marketed at optimum weights. (4) Other livestock production costs for the same reasons would be lowered slightly. (5) The overhead costs of transporting, processing and distributing a more uniform supply of livestock and livestock products would be lower by several percent. (6) Consumers would have a more uniform supply of meat and livestock products—more when there otherwise would be a relative scarcity, less when market supplies would otherwise be

burdensome. Taken all together, the benefits appear to be several times greater than the costs.

APPENDIX A

FACTORS DETERMINING HOG PRICES

In analysing hog prices, a minimum of two explanatory causative series is required—the one representing changes in demand, and the other representing changes in supply.

The two most comprehensive and accurate series to represent hog supplies and prices are probably the "Total live weight of hogs slaughtered under Federal inspection in the United States," and the "Average cost to packers in the United States—dollars per 100 pounds" (i.e., the price to farmers) published monthly by the Bureau of Agricultural Economics.

The federally inspected slaughter is only about 65 percent of the total slaughter, but the total slaughter figures have some serious shortcomings. It is a question whether hogs slaughtered and consumed on farms have the same price determining influence as hogs slaughtered in commercial channels. Moreover, the total slaughter estimates are made only on the calendar year basis, and they are not available as currently as the federally inspected slaughter data; in the 1937 Agricultural Year Book, for example, they are given only up to 1933. Altogether, the federally inspected slaughter figures are more satisfactory for statistical analysis.

The choice of a series to represent changes in demand has been, until recently, a more troublesome matter. Various indexes have been available for some time—indexes of industrial production, industrial payrolls, etc.—but perhaps the most satisfactory series is the monthly estimates of total non-agricultural income in the United States recently published by the AAA.[23]

This series reflects changes in domestic demand, but the total demand for hogs consists of two elements: domestic demand and foreign demand. An additional series is needed, then, to represent changes in foreign demand. The amounts exported each year do not represent foreign demand; they

[23]Bean, L. H., Bollinger, P. H., Wells, O. V. Non-Agricultural Income as a Measure of Domestic Demand, AAA, BAE. June, 1937.

represent foreign consumption, which responds to changes in supplies (and therefore prices) as well as to changes in demand.

A rough and ready means of converting these foreign consumption data into foreign demand data is available, however. Increased exports accompanied by lower prices would not be evidence of increased foreign demand; but increased exports accompanied by constant or even higher prices would be definite evidence that foreign demand had increased. If the

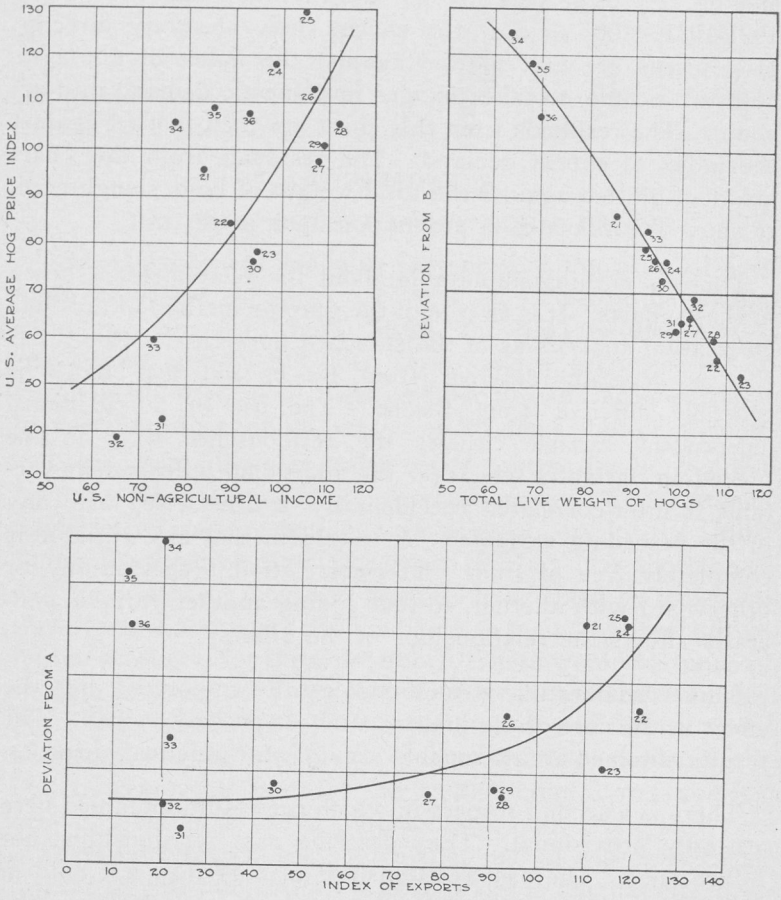

Fig. 19. (A, left—B, bottom—C, right). Average price of hogs, total non-agricultural income, value of hog products exports and total live weight of hogs slaughtered under federal inspection, United States, 1922 to 1936.

elasticity of the export demand were unity, a good index of foreign demand could be constructed by multiplying the amount exported each year by the price. The actual elasticity is unknown and is so difficult to ascertain that we merely assume an elasticity of unity and multiply the exports by the prices. The results are purely provisional, but serve a useful purpose until such time as a more accurate index of foreign demand is available.

The results of the use of these series are shown in table 5 and fig. 19. The data are all thrown into index form, base, 1921-1931=100, so that the charts show elasticity directly. Hog prices are first plotted against the index of non-agricultural income, to take changes in domestic demand into account. The residuals from this chart are then plotted against the index of export demand. The residuals from this chart are then plotted against the total weight of hogs slaughtered, to show the influence of production upon price.

There is nothing immutable about the relationships shown in these charts. It is as true of the graphic method of multiple correlation analysis as of the standard numerical method that Bxa is generally different from Bxa.b, and that Bxa.b is generally different from Bxa.bc. The use of an additional independent variable changes the relationships of x to the preceding variables whenever the additional independent variable is inter-correlated (accidentally or otherwise) with any of the preceding variables. It is seldom that any variable is completely free of some inter-correlation (accidentally or otherwise) with another, so that adding another variable generally affects the relationships of the others.

This consideration is methodologically important, but the effect in the case of the present study is probably small. The results obtained are reasonably accurate for practical purposes.

There is a second respect in which the results obtained here are only provisional. They describe past relationships, not future ones. The past relationships may or may not hold in the future. This subject is discussed in some detail in the next section of this Appendix, dealing with corn prices.

TABLE 5. INDEXES OF HOG PRICES, NON-AGRICULTURAL INCOME, EXPORTS AND HOG SLAUGHTER, 1921-1937

(Base equals 1921-1931 average)

	Average hog price	Total U. S. non-agricultral income	Index of exports times hog prices	Live weight of U. S. hog slaughter
	Oct.-Sept.	Oct.-Sept.	July-June	Oct.-Sept.
1921-22	95.7	83.3	110.0	86.8
1922	84.3	89.2	121.6	108.4
1923	78.3	94.8	113.6	113.8
1924	118.1	98.4	119.0	97.2
1925	129.5	104.8	118.4	92.6
1926	113.1	106.8	93.8	94.8
1927	97.6	107.8	77.3	102.5
1928	105.7	112.2	92.9	107.5
1929	101.1	108.9	91.4	99.8
1930	76.4	94.0	44.6	96.6
1931	42.8	75.0	24.6	100.7
1932	38.9	65.3	20.7	103.4
1933	59.6	73.0	22.2	93.5
1934	105.6	77.2	20.3	63.9
1935	108.9	85.4	12.8	68.1
1936-37	107.7	92.9	13.5	70.1

APPENDIX B

FACTORS DETERMINING CORN PRICES

Several series are available to represent the price of corn. One could use the price of corn at Chicago, the average farm price for the United States, for Iowa in the heart of the surplus area or still other series, and in each case the decision would need to be made whether to use December prices or average prices for the season or for some shorter period.

These series all yield similar results, except for slight differences in the elasticity of the demand curves. The series finally selected was the average farm price of corn for the United States for a period from December to May. (A shorter period, for instance 1 month, is likely to be affected by ephemeral forces, while a longer period is likely to include prices affected by the prospects for the next crop.) There would be some advantage in using an Iowa farm price or a western Corn Belt farm price, since that is where the bulk of the surplus would be stored, but the hog prices used in the hog section of this bulletin represent prices for the whole United States, and it is probably better to use a United States corn price, too.

Previous research has shown that one of the chief causes of year-to-year fluctuations in corn prices is fluctuations in the size of the United States corn crop plus the carryover of old corn from the previous crop, both on the farm and in commer-

cial channels. The Bureau of Agricultural Economics prepares estimates which take some other minor factors into account as well (exports, imports, etc.). Their series is accordingly used, to show changes in the production of corn from one year to the next.

The experience of the past few years has shown that changes in the demand for corn have a great effect upon the price of corn. What series should be used to represent the demand for corn? The index of the general price level is sluggish and in any case is an inaccurate index of demand. The index of the general price level may remain constant while the demand for corn is changing. During an industrial boom, for example the boom in 1928 and 1929, demand increased greatly, but the general price level did not rise. The index of total national income also is too sluggish to represent changes in the demand for a speculative, durable commodity such as corn. Indexes of employment or payrolls are moderately good measures of demand, but they measure only part of the demand and a non-constant part at that.

A different approach to the measurement of demand may be considered. The demand for corn is a result of two forces: the demand for farm products in general, as from changes in industrial activity and the demand for corn itself, as affected, for instance, by changes in livestock numbers.

That is, changes in the general demand for farm products may carry corn prices up or down with all other farm product prices; in addition, changes in the demand for corn alone may carry its price above or below other farm products prices. Both movements need to be measured.

Accordingly, we used the index of farm products prices as a measure of the general demand for farm products and the numbers of livestock as the measure of the particular demand for corn, fluctuating about the general demand. There are objections to these measures also, but they were considered not as weighty as those against the other measures discussed above.

Strictly speaking, the statistical analysis on which this bulletin is based merely describes the relations that existed during the period 1922-1936. There is no guarantee that these

relations will continue identically the same in the future as in the past. The price level may change, farming systems may change, substitute feeds may be developed, the composition of the livestock population that consumes the bulk of the corn may change, in fact is changing, and so on.

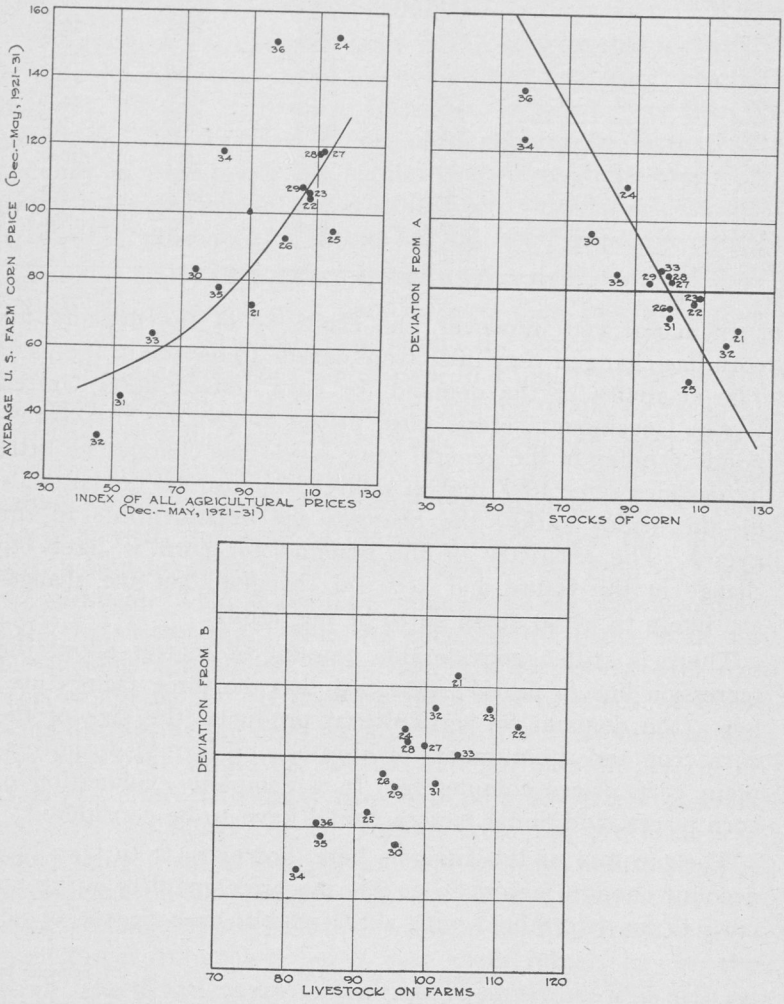

Fig. 20. (A, left—B, right—C, bottom). Average farm price of corn, December to May, prices of farm products December to May, total corn production and numbers of livestock on farms Jan. 1, United States, 1922 to 1930.

TABLE 6. AVERAGE FARM PRICE OF CORN DECEMBER TO MAY, AVERAGE PRICES OF FARM PRODUCTS DECEMBER TO MAY, TOTAL CORN PRODUCTION AND NUMBERS OF LIVESTOCK ON FARMS JAN. 1, UNITED STATES, 1921 TO 1936.

	Average U. S. farm price of corn	Index of all ag. prices	Numbers of livestock on farms	Corn production plus stock of old corn
	Dec.-May	Dec.-May	Jan. 1	Dec. 1
1921-1922	72.9	91.0	1044	1197
1922	104.8	108.1	1131	1068
1923	106.4	108.1	1094	1088
1924	152.9	115.7	971	872
1925	95.2	114.9	918	1060
1926	93.1	100.6	940	1001
1927	119.0	111.9	999	1006
1928	118.1	110.4	974	994
1929	108.1	105.9	957	942
1930	83.2	74.1	957	770
1931	45.4	52.2	1014	1000
1932	33.9	45.4	1013	1163
1933	64.0	61.3	1045	974
1934	118.5	81.6	818	577
1935	78.3	80.9	852	846
1936-37	151.3	96.8	845	572

In actual fact, however, the elasticity of the demand for corn has changed very little from decade to decade in the past. The elasticity of the demand for corn (based upon United States December average farm prices divided by the corresponding index of the general price level) has changed so little by decades since 1897 that in a three dimensional model made by the senior author the changes are imperceptible to the eye.[24] The elasticity of the demand for corn is likely to change in the future and keep on changing, but the changes are likely to be so small as to be negligible.

There is still a considerable amount of scatter about the regression line in fig. 17, indicating that the three factors used here (the demand for agricultural products, the size of the corn crop and the numbers of livestock on farms) do not explain corn prices completely. In a complete explanation of corn prices, additional factors would have to be considered.

The purpose of the analysis here, however, is to take into account enough factors to enable the price-quantity curve for corn to be determined with a reasonably high degree of ac-

[24]Henry Schultz found a considerable change in the elasticity of the demand for corn after the World War (from -.6982 before the War to -.4924 after it). But his analysis was based on United States farm prices, and his post-war period was only 8 years long, his results being affected (the elasticity reduced) by the runaway bull market in wheat and corn in the winter of 1924-25. See his article "The Shifting Demand for Selected Agricultural Commodities, 1875-1929." Journal of Farm Economics, Vol. XIV, No. 2, April, 1932.

curacy. The three factors used accomplish this purpose; a complete explanation would require more time than is available for the present study.

APPENDIX C

EFFECT OF CORN LOANS ON STABILITY OF TOTAL INCOME

It was shown in the main body of the bulletin that a change in the size of the corn crop causes a greater (opposite) change in price. A big corn crop, therefore, is worth less than a small crop. Fluctuations in corn production cause fluctuations not only in corn prices but in the total value of the crop. A national storage program that stabilized corn supplies would thereby stabilize, not only corn prices, but also total corn crop values.

But this stabilizing effect upon total values would follow only if the program were handled as a crop insurance program, with the premiums paid in and the benefits paid out in kind. In that case, the surplus corn in a big crop year would be "paid in" as a premium, and no income would be received from it until a short crop year, when it would be "paid back."

If the program were handled as a corn-loan program, total values would not be thus stabilized from year to year.[25] In a big crop year, the value of the loans made upon the surplus corn would be added to the total value of the crop that was not withheld. That is, the total value of the big crop would be 100 (that is, average) plus the value of the loans made on the surplus corn, which in the case of a 20 percent over-size crop would be 20. If farmers spent the proceeds of these loans during the big crop disposal year, the total value of the crop that year would be, not 100 percent, but 120 percent of average. Then if the next crop were only 80 percent of average size, the release of the surplus from the previous year would bring it up to 100 percent, and its price and total value would each be 100 percent. But as far as the farmer would be concerned, the proceeds of the sale of his 20 percent surplus carried over from the previous year would merely pay off the loan. The actual value of the crop to him would be only 80 percent of average, not 100 percent.

[25]This point was drawn to our attention by D. A. Fitzgerald, Hog Section, AAA.

If the corn storage program were put into effect by means of loans, therefore, it would stabilize the price of corn, the amount consumed and the total value of the amount consumed, but it would not stabilize farm incomes. If the value of the loans is included, it would increase the total value of the crop (meaning the total value of the crop plus the value of the loans) in big crop years and decrease it in small crop years. The total value would in fact fluctuate as much as the size of the crop fluctuated. A crop 120 percent of average size would have a total value (inclusive of loans) 120 percent of average size; a crop 80 percent of average size would have a total value 80 percent of average size and so on for all other size crops. This would be the reverse of the present situation, under which small crops are worth more than large crops.